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(54) **SENSOR FOR IMAGING INSIDE EQUIPMENT**

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USPC 348/373, 82, 83, 86, 125; 705/305; 702/33, 34, 35, 36, 40, 184, 185, 188
See application file for complete search history.

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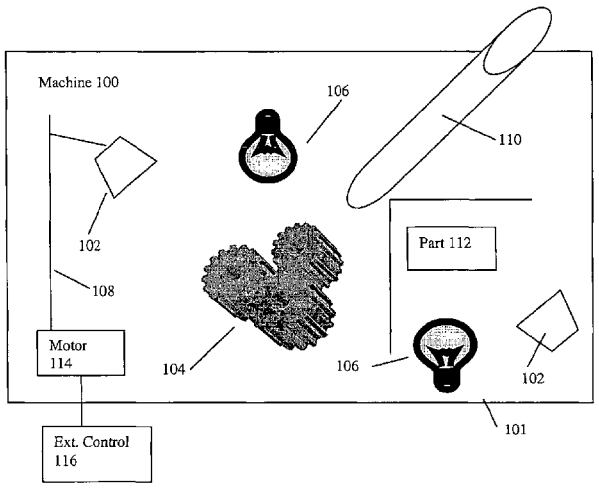
(57) **ABSTRACT**

A system for monitoring performance of a machine for detection of visible signs of failure, includes: a machine enclosure housing machine parts; at least one canal through the machine enclosure acting as a visual conduit for providing a view into the interior of the machine; a guide rail within the canal for moving a camera into the interior; an interface to the machine configured to receive images from the visual conduit; and a repair network for linking the interface to a monitoring center that provides for the repair of problems with the machine.

13 Claims, 4 Drawing Sheets



(51) **Int. Cl.**

G06Q 10/00	(2012.01)
G07C 3/00	(2006.01)
H04N 7/18	(2006.01)
G01N 21/954	(2006.01)
G01N 21/01	(2006.01)

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CPC *G01N2021/889* (2013.01); *G01N 2201/06* (2013.01); *G01N 2201/08* (2013.01)

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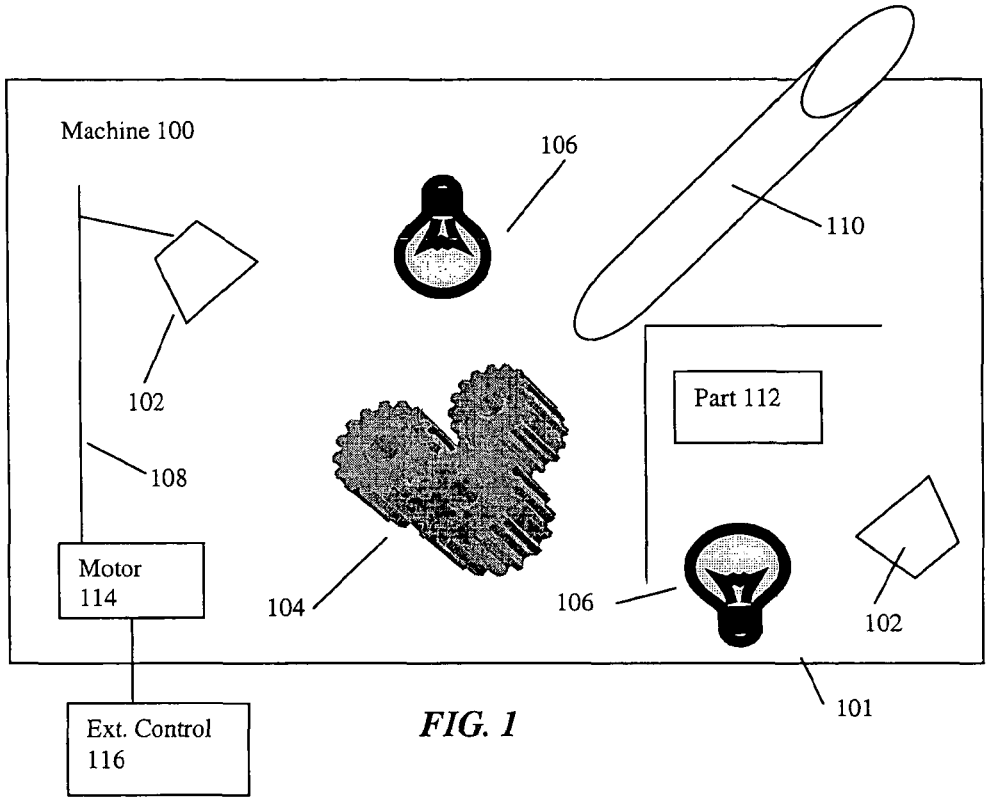
Machine 100
106
110
102
Part 112
108
Motor
114
104
106
102
101
Ext. Control
116

FIG. 1

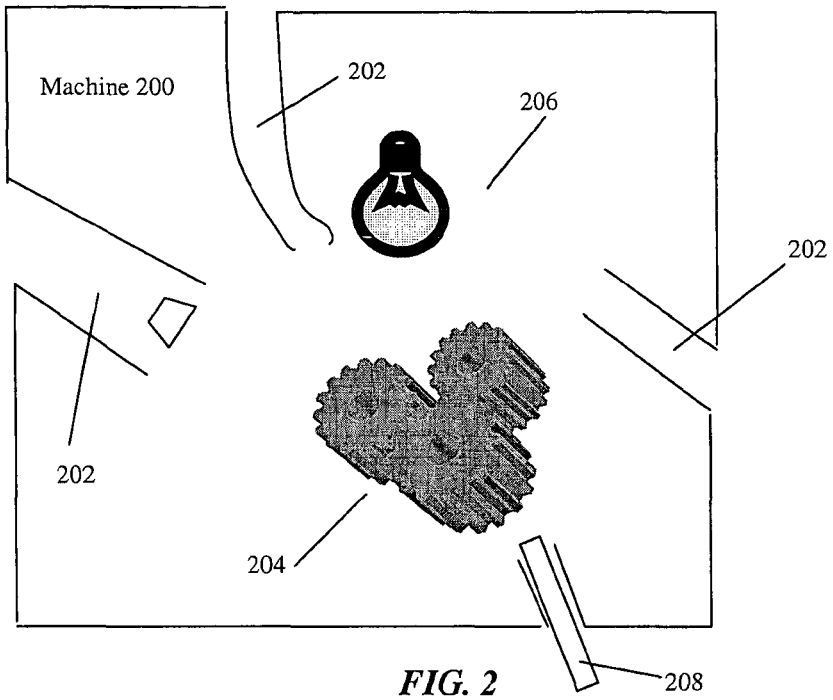

FIG. 2

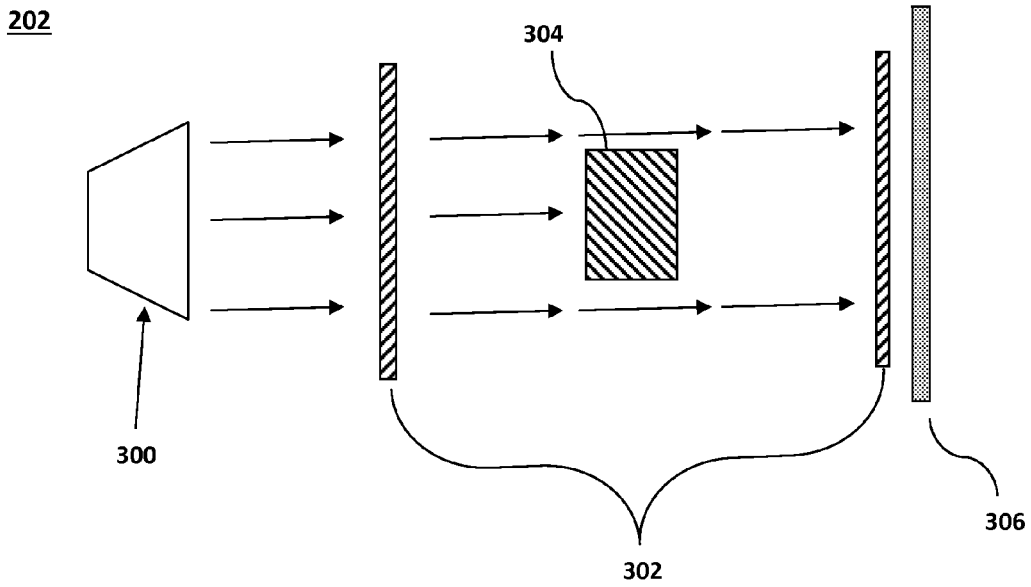

FIG. 3

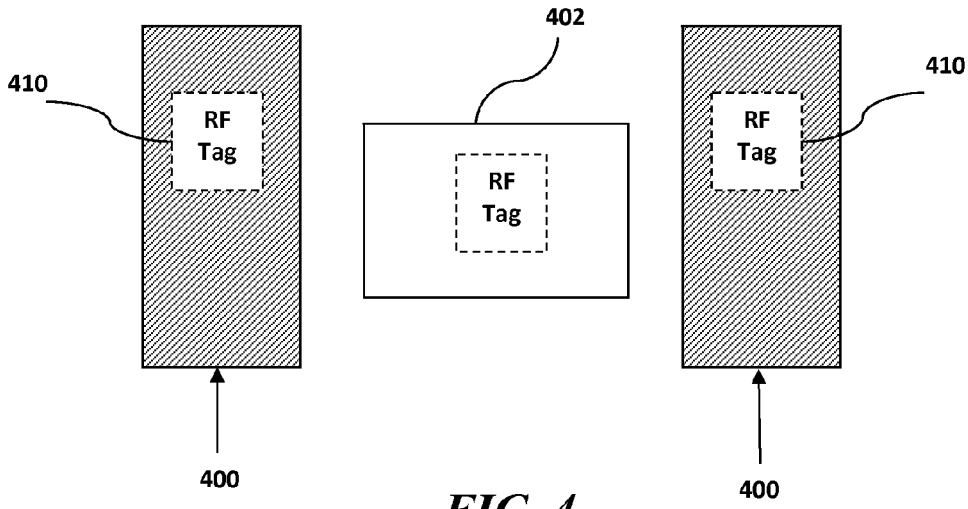

FIG. 4

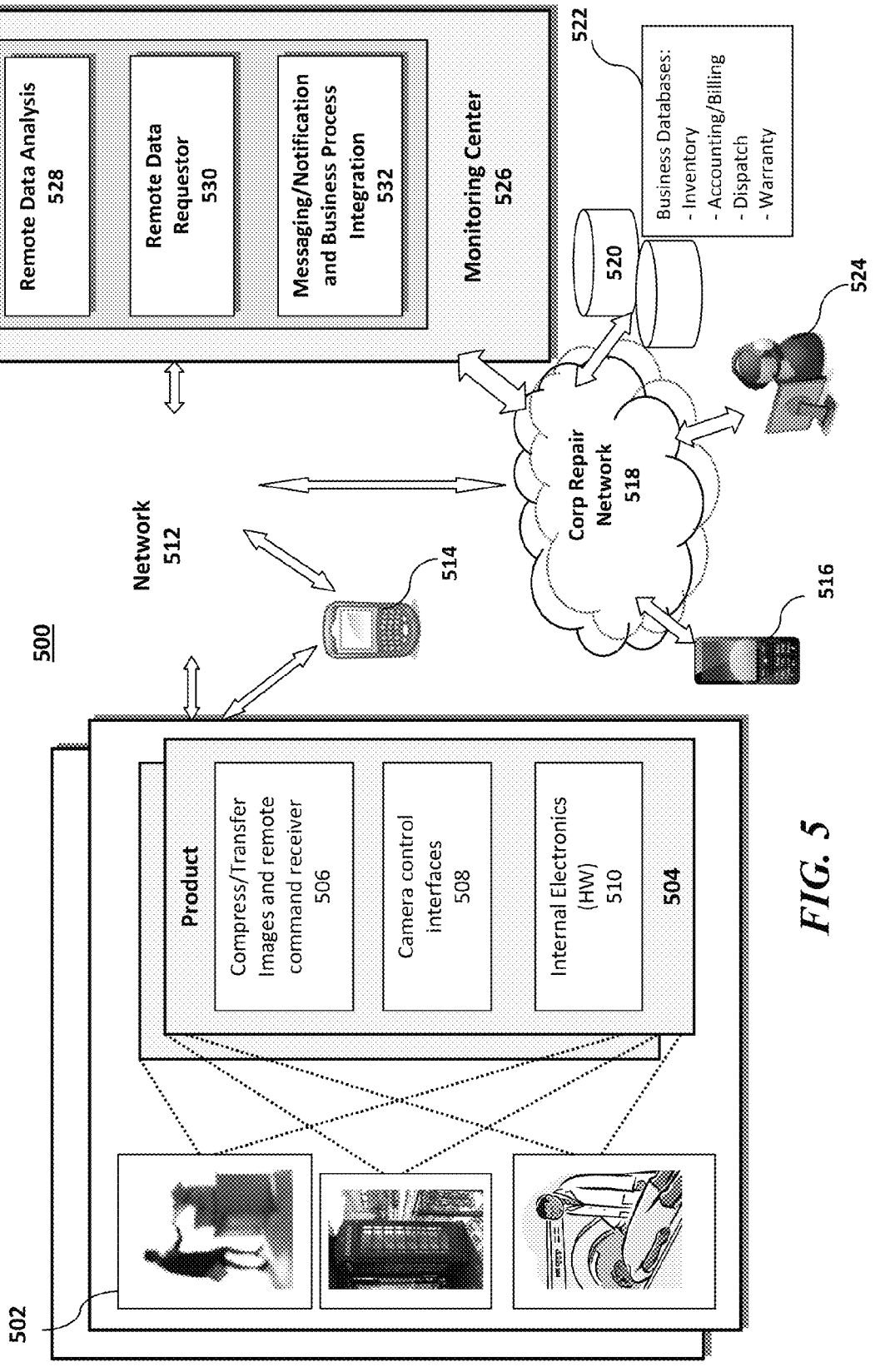
500
502
Product
Compress/Transfer Images and remote command receiver 506
Camera control interfaces 508
Internal Electronics (HW) 510
504
Network 512
514
516
Corp Repair Network 518
520
522
Business Databases:
- Inventory
- Accounting/Billing
- Dispatch
- Warranty
524
Monitoring Center 526
Remote Data Analysis 528
Remote Data Requestor 530
Messaging/Notification and Business Process Integration 532

FIG. 5

SENSOR FOR IMAGING INSIDE EQUIPMENT

CROSS-REFERENCE TO RELATED APPLICATIONS

This application is a continuation of, and claims priority to, U.S. patent application Ser. No. 13/052060, filed on Mar. 19, 2011, which is a division of, and claims priority from, U.S. application Ser. No. 12/330443, now U.S. Pat. No. 7,952,641, which claims priority from U.S. application Ser. No. 10/874,022, now U.S. Pat. No. 7,502,068.

FIELD OF THE INVENTION

The invention disclosed broadly relates to the field of machines and more particularly relates to the field of diagnosis of problems in machines.

BACKGROUND OF THE INVENTION

When a machine breaks down, it may be difficult and expensive to repair because disassembly may be required to diagnose the problem. There is also a frequent delay in obtaining parts to replace those broken once the problem has been diagnosed. The resulting down time is also a problem.

Remote monitoring of equipment needs different kind of sensors. Common sensors today include temperature sensors, weight sensors, position sensors, etc. The data from these sensors can be remotely viewed to diagnose the condition of the system. However, there are still situations where these sensors are not adequate to diagnose the problem and is necessary for a human being to open up the equipment and look at it. This process is time consuming and there needs to be a better way. The idea is to use imaging inside the equipment to handle situations that cannot be addressed by the above means.

SUMMARY OF THE INVENTION

Briefly, according to the invention, a machine comprises an enclosure; a plurality of parts within the enclosure; and a visual conduit for providing a view inside of the enclosure for detection of visible signs of failure of the machine. The concept of a visual conduit encompasses a broad variety of devices including cameras inside the enclosure that provide images of the interior of the enclosure and alternatively selective transparency or translucence of the enclosure relative to at least some of the parts of the machine housed within the enclosure.

According to another embodiment of the invention a method for designing a machine comprises the steps of: selecting a first material for an enclosure; and selecting a second material for one or more parts within the enclosure; wherein the selection of the materials permits viewing of the parts under certain conditions.

According to another embodiment of the invention a system comprises an interface for receiving images from remote devices; one or more central servers for storing the images for further analysis using image processing techniques; and a transmitter for further distribution of the images to other destinations.

BRIEF DESCRIPTION OF THE DRAWINGS

To describe the foregoing and other exemplary purposes, aspects, and advantages, we use the following detailed description of an exemplary embodiment of the invention with reference to the drawings, in which:

FIG. **1** shows a machine with sensors according to the invention.

FIG. **2** shows a highly-simplified depiction of a machine according to another embodiment of the invention.

FIG. **3** shows a cross-section of a machine with parts made form materials with different properties.

FIG. **4** shows a machine with parts made form materials with different properties wherein RF-tags are embedded in the parts to identify the materials.

FIG. **5** shows system architecture according to the present invention.

While the invention as claimed can be modified into alternative forms, specific embodiments thereof are shown by way of example in the drawings and will herein be described in detail. It should be understood, however, that the drawings and detailed description thereto are not intended to limit the invention to the particular form disclosed, but on the contrary, the intention is to cover all modifications, equivalents and alternatives falling within the scope of the present invention.

DETAILED DESCRIPTION

FIG. **1** shows a highly-simplified depiction of a machine **100** with sensors according to the invention. The machine **100** comprises an enclosure or housing **101** for machinery **104**. In this embodiment, the sensors comprise a set of cameras **102**, all located within the machine enclosure **101** to capture images of the machinery **104**. Assume that the machine **100** is an expensive piece of equipment such as a printer, magnetic resonance imaging device or the like. In this case a set of parts **104** is malfunctioning. The camera **102** is used to diagnose the problem. In this case assume that the machinery **104** comprises mechanical moving parts and failures can be easily detected by obtaining images of the parts **104** by means of the camera **102** using the light **106** to illuminate the parts. Because the enclosure of the machine need not be opened during a diagnosis operation, the machine can continue to operate showing the cause of failure. Assume that the machine parts **104** are a set of gears and one of the gears is missing a cog. The images produced by the camera **102** are provided to a user outside the machine who can easily determine the cause of the failure. As will be appreciated, the light source **106** may not be required where the camera **102** obtains images using infrared radiation produced by the parts **104** when they are hot as a result of their operation.

The camera **102** can be a still or preferably a video camera with flash, zoom, and other such features. It is preferably controlled by external controls **116**. The camera **102** can be mounted on a track **108** and coupled to a motor **114** that is controlled by the external controls **116**. The user is presented with the images provided by the camera **102** and can thus interactively control the orientation and movements of the camera to provide the desired images of the machine parts **104**.

The camera **102** has a unique identifier (ID) and a wired or wireless link to the outside world for communication with a user. The unique identifier is transmitted to the outside world so that each machine can be identified from other nodes in the network. Alternatively, the camera **102** may be programmed to move automatically providing a set of images that may be stored and later viewed on demand to determine what caused a failure in the past. The light **106** can also be programmed to move automatically or can be moved manually by means of the external control apparatus **116**.

An alternative image conduit is provided by a tube **110** having an internally reflective surface (preferably fiber optics) that transmits an image or images of the interior of the machine **100** to the outside. Such a tube **110** can include a camera and light as well. The tube is preferably flexible so that it can negotiate winding paths throughout the machine **100**.

The cameras can be placed in locations where even highly obscured parts (such as part **112**) can be imaged.

Referring now to FIG. **2**, there is shown a machine **200** according to another embodiment of the invention. In this embodiment, the visual conduit **202** includes a plurality of pathways or canals that are provided throughout the machine to provide images of its interior. As in the case depicted in FIG. **1**, a canal **202** provides an image of the machine parts **204** to its users to assist in determining whether the parts are operating properly. A light source **206** provides illumination where necessary. Optional camera guide rails or paths **208** are provided in one of the canals **202** to allow for movement of a camera (not shown) to locations required for providing the desired images. Thus, a camera can be sent through the pathways **208** for providing images throughout the inside of the machine.

Referring to FIG. **3**, there is shown another embodiment of the invention wherein the visual conduit **202** includes a machine enclosure **302** made from a material that is transparent to a source of electromagnetic radiation (EMR) **300** at one or more frequencies such as x-ray frequencies. Thus the radiation source **300** provides x-rays that pass through the enclosure **302** relatively unimpeded but are substantially blocked by a machine part **304** that is made from a different material that is opaque to the EMR. The result is an image of the machine part **304** that can be captured at a sensor **306** outside the enclosure **302**. An example of a sensor is a film that is sensitive to x-rays. The sensor can be located inside the enclosure **302** and connected to the outside by a communication link to provide the images acquired. The film **306** can be optionally replaced by a sensor (such as charge-coupled devices) that detects the EMR that passes through enclosure **302**, and provides the image to the world outside the enclosure.

Referring to FIG. **4**, there is shown another embodiment of the invention wherein the machine enclosure **400** is made from a different material than the interior parts **402** and radio-frequency tags **410** are embedded in the parts **402** to provide an indication of the material from which they are made. An RF-tag reader (not shown) can be used from outside the enclosure **402** to read the information stored in the RF-tag **410**. This provides user information that can be used to determine the properties of the materials so that the user can select an appropriate visualization tool (e.g. x-rays).

FIG. **5** shows system architecture **500** of a system that uses the invention to diagnose problems in machines. The system **500** monitors a set of equipment **502** for purposes of maintaining its operation. The equipment **502** comprises machines having parts within their interiors that are monitored by means of visual conduits as discussed above. The equipment **502** is typically expensive to repair because of the trouble-shooting required. Each item of equipment **502** interfaces with a network **512** by means of an interface **504**. The interface **504** comprises a module **506** for compressing/transferring images and receiving remote commands. A module **508** comprises camera control interfaces for controlling the location and orientation of the cameras located inside the equipment and a module **510** comprising the internal electronics for controlling the operation of the visual conduits.

The interface **504** is linked, via a wireless link, with a personal digital assistant **514**; and via the network **512** to a monitoring center **526**. The monitoring center **526** includes: a remote data analysis module **528**; a remote data requester **530**; and a messaging/notification and business process integration module **532**. The remote data analysis module **528** receives data originating from the monitored machine **502** and transmits the data to a corporate repair network **518**. From there, the data can be stored in persistent storage **520**, in proprietary business databases **522**, downloaded to mobile devices **516** such as cell phones, or downloaded directly to the systems of users **524** who monitor the performance of the machines **502**. The remote data requester **530** can be used by a user to request data gathered by sensors monitoring the machines.

The messaging/notification and business process integration module **532** is used to coordinate the tasks performed using various enterprise business applications that may not have compatible syntax or data structures. Module **532** can comprise software such as IBM's WebSphere Business Integration™ software or MQ Series.

What has been shown and discussed is a highly-simplified depiction of a programmable computer apparatus. Those skilled in the art will appreciate that other low-level components and connections are required in any practical application of a computer apparatus.

Therefore, while there has been described what is presently considered to be the preferred embodiment, it will be understood by those skilled in the art that other modifications can be made within the spirit of the invention.

We claim:

1. A system for monitoring performance of a machine for detection of visible signs of failure, the system comprising:

a machine enclosure housing a plurality of machine parts disposed within an interior of the machine;

at least one canal through the machine enclosure, said at least one canal acting as a visual conduit for providing a view into the interior of the machine;

a guide rail within the canal to facilitate movement of a camera into the interior of the machine; and

a repair network for linking to a monitoring center to provide for the repair of problems with the machine.

2. The system of claim **1**, wherein a second canal comprises a flexible tube.

3. The system of claim **1**, wherein a second canal comprises a tube with an internally reflective surface.

4. The system of claim **3**, wherein the second canal comprises a fiber optics cable.

5. The system of claim **1**, further comprising a light source within the at least one canal.

6. The system of claim **1**, further comprising at least one sensor disposed inside the machine enclosure.

7. The system of claim **6**, wherein the at least one sensor includes a second camera.

8. The system of claim **1**, wherein the visual conduit comprises a material that is transparent to a source of electromagnetic radiation at one or more frequencies.

9. The system of claim **1**, wherein the camera is mountable on the guide rail.

10. The system of claim **9**, wherein the camera is configured to move along the guide rail automatically in accordance with a program.

11. The system of claim **1**, further comprising a motor to control movement of the camera.

12. The system of claim **1**, further comprising an external controller to control movement of the camera.

13. The system of claim **1**, wherein the camera is an infrared camera.

* * * * *